theta-band activity (two indicators of drowsiness), and episodes of stage 2 and 3 sleep. The figure shows that in the sampled 15-minute periods at 5:40 a.m. and 6:40 a.m., the Control Group pilots were either asleep (stage 2 or 3) or exhibiting significant sleepiness (EEG theta activity) 20%–25% of the time. Conversely, the Treatment Group pilots, who had just received a 7-minute break, fell asleep or exhibited significant sleepiness for less than 5% of the time during the same two periods. Furthermore, higher numbers of Control subjects exhibited sleepy behaviors during these two time periods (12 of 14 subjects) than Treatment subjects (no more than 7 of 13 subjects).

Overall, the physiological data were consistent with subjective reports in indicating that brief, controlled activity breaks were effective in reducing nighttime sleepiness for at least 15 minutes post-break. The breaks provided particular benefits during the early morning hours—the circadian time associated with the greatest vulnerability to fatigue. Furthermore, the breaks continued to mask any underlying sleepiness for up to 25 minutes post-break. The physical activity that occurred as part of the breaks most likely produced enough sympathetic nervous system activation to produce an EEG response characteristic of increased arousal.

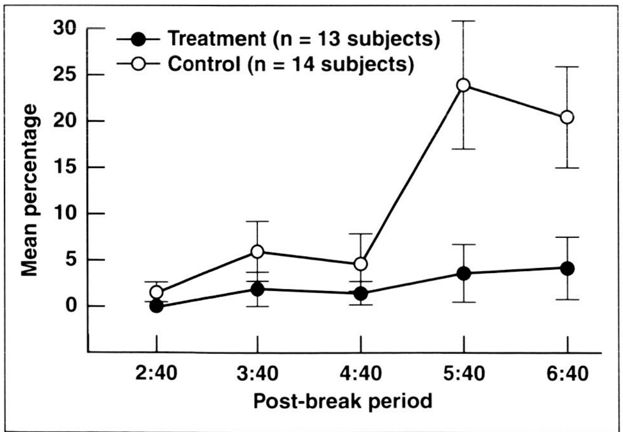

Fig. 1. Mean percentage (±1 s.e.m.) of combined EEG theta activity and stage 2 or 3 sleep exhibited by pilots on the flight deck during the 15-minute period following a controlled activity break (Treatment Group) or during a corresponding time period (Control Group). The Control Group received only the middle break (ending at 4:40 a.m.).

Controlled activity breaks are not substitutes for adequate sleep, but they do represent a practical, short-term countermeasure to the fatiguing effects of a long nighttime flight, provided appropriate controls are in place to ensure the wakefulness and alertness of the other crewmembers remaining on the flight deck.

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Communication Strategies for Correcting Errors

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Maintaining safety in high-risk engineered environments like aviation is a team effort that depends crucially on the team members' efficiency in monitoring each other's performance and on their effectiveness in intervening if they consider a decision or action to be unsafe. Unfortunately, analyses of aviation accidents and incidents indicate that pilots, in particular junior pilots, have frequently failed in this important crew function, especially in situations in which their interventions posed a direct challenge to the other crewmember's judgment and decision-making skill. In such situations, junior crewmembers will sometimes only hint at the possibility of a problem rather than tell the captain explicitly to perform a corrective action.

This kind of communication failure has been identified as a "monitoring/challenging error" by the National Transportation Safety Board (NTSB) and was found to occur in over 75 percent of the accidents reviewed. Moreover, monitoring/challenging failures appear to contribute to "plan continuation errors." These are errors in which the crew continues with its planned course of action in the face of cues suggesting that the plan should be reconsidered. The research reported here is an effort to understand communication strategies for correcting crew errors, and looks at differences in strategies as a function of crew position (captain vs. first officer) and of risk and face-threat posed by the problem.

Three studies were conducted to determine (1) what strategies captains and first officers indicate they would use to correct errors in hypothetical situations, (2) what strategies captains and first officers judge most effective in getting them to change their own behavior, and (3) what kinds of communication strategies pilots actually use when confronted with errors in simulated flights. The first two studies were paper and pencil tasks and the third was conducted in a 747-400 simulator.

It was hypothesized that captains would be more direct in correcting first officers than first officers would be in mitigating errors by the captain. However, for both crew positions communications were expected to be more direct during high-risk or emergency situations than during low-risk incidents. In addition to risk, pilots' communications were hypothesized to be sensitive to the degree to which an error implied a threat to the professional "face" of a crewmember. If the other pilot has made an obvious error, calling attention to it may involve a direct challenge to the pilot's status, judgment, or skill. In situations like these, politeness dictates the use of more indirect speech than would be the case in situations that are less face-threatening.

In the first paper and pencil task, participating pilots received descriptions of aviation incidents and were asked to state how they would correct various pilot errors. As predicted, captains were more direct than first officers were: they predominantly used commands, whereas first officers preferred to use hints. The risk level also influenced pilot interventions in the predicted direction: captains and first officers were more direct in high-risk situations. In contrast, pilot responses to varying levels of face-threat of the incidents were not consistent with the predictions made by politeness theory.

The second paper and pencil task examined which types of communication would be most effective in correcting pilot errors. Pilots were asked to rate how effective various communication strategies would be in getting them to carry out the speaker's intent. As shown in figure 1, both captains and first officers favored communications that appealed to a crew concept rather than to any particular status-based model, and consistently rated commands, the most direct communication strategy, as less effective than crew suggestions or preferences.

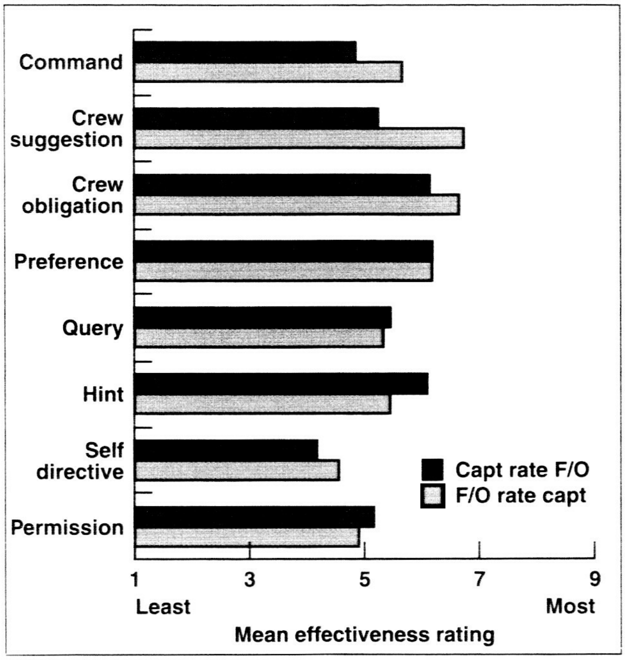

Fig. 1. Captain and first officer mean effectiveness ratings of different communication types.

The third study examined pilot error-challenging strategies during a full-mission simulation study. Errors based on those used in the paper and pencil tasks were scripted into flight scenarios, which participating pilots flew with a research confederate pilot trained to perform the scripted errors. The results of this study indicate that both captains and first officers used error-correcting strategies that supported a positive crew climate, such as strong hints and suggestions. As expected, both captains and first officers were sensitive to risk, and communicated more directly when risk was high. The influence of face-threat was somewhat different for captains and first officers, as expected from their differences in rank.

These findings, which have identified the strategies most effective for mitigating errors in the cockpit, can aid in the development of training under the safety program that helps pilots develop more effective error-correction strategies.

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